

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE
ENERGY SUBCOMMITTEE**

HEARING CHARTER

Economic Aspects of Nuclear Fuel Reprocessing

**July 12, 2005
2 p.m. – 4 p.m.
2318 Rayburn House Office Building**

1. Purpose

On Tuesday, July 12, the Energy Subcommittee of the House Committee on Science will hold a hearing to examine whether it would be economical for the U.S. to reprocess spent nuclear fuel and what the potential cost implications are for the nuclear power industry and for the federal government. This hearing is a follow-up to the June 16 Energy Subcommittee hearing that examined the status of reprocessing technologies and the impact reprocessing would have on energy efficiency, nuclear waste management, and the potential for proliferation of weapons-grade nuclear materials.

2. Witnesses

Dr. Richard K. Lester is the Director of the Industrial Performance Center and a Professor of Nuclear Science and Engineering at the Massachusetts Institute of Technology. He co-authored a 2003 study entitled, *The Future of Nuclear Power*.

Dr. Donald W. Jones is Vice President of Marketing and Senior Economist at RCF Economic and Financial Consulting, Inc. in Chicago, Illinois. He co-directed a 2004 study entitled, *The Economic Future of Nuclear Power*.

Dr. Steve Fetter is the Dean of the School of Public Policy at the University of Maryland. He co-authored a 2005 paper entitled, *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*.

Mr. Marvin Fertel is the Senior Vice President and Chief Nuclear Officer at the Nuclear Energy Institute.

3. Overarching Questions

- Under what conditions would reprocessing be economically competitive, compared to both nuclear power that does not include fuel reprocessing, and other sources of electric power? What major assumptions underlie these analyses?
- What government subsidies might be necessary to introduce a more advanced nuclear fuel cycle (that includes reprocessing, recycling, and transmutation—“burning” the most radioactive waste products in an advanced reactor) in the U.S.?

4. Brief Overview of Nuclear Fuel Reprocessing (from June 16 hearing charter)

- Nuclear reactors generate about 20 percent of the electricity used in the U.S. No new nuclear plants have been ordered in the U.S. since 1973, but there is renewed interest in nuclear energy both because it could reduce U.S. dependence on foreign oil and because it produces no greenhouse gas emissions.
- One of the barriers to increased use of nuclear energy is concern about nuclear waste. Every nuclear power reactor produces approximately 20 tons of highly radioactive nuclear waste every year. Today, that waste is stored on-site at the nuclear reactors in water-filled cooling pools or, at some sites, after sufficient cooling, in dry casks above ground. About 50,000 metric tons of commercial spent fuel is being stored at 73 sites in 33 states. A recent report issued by the National Academy of Sciences concluded that this stored waste could be vulnerable to terrorist attacks.
- Under the current plan for long-term disposal of nuclear waste, the waste from around the country would be moved to a permanent repository at Yucca Mountain in Nevada, which is now scheduled to open around 2012. The Yucca Mountain facility continues to be a subject of controversy. But even if it opened and functioned as planned, it would have only enough space to store the nuclear waste the U.S. is expected to generate by about 2010.
- Consequently, there is growing interest in finding ways to reduce the quantity of nuclear waste. A number of other nations, most notably France and Japan, “reprocess” their nuclear waste. Reprocessing involves separating out the various components of nuclear waste so that a portion of the waste can be recycled and used again as nuclear fuel (instead of disposing of all of it). In addition to reducing the quantity of high-level nuclear waste, reprocessing makes it possible to use nuclear fuel more efficiently. With reprocessing, the same amount of nuclear fuel can generate more electricity because some components of it can be used as fuel more than once.

- The greatest drawback of reprocessing is that current reprocessing technologies produce weapons-grade plutonium (which is one of the components of the spent fuel). Any activity that increases the availability of plutonium increases the risk of nuclear weapons proliferation.
- Because of proliferation concerns, the U.S. decided in the 1970s not to engage in reprocessing. (The policy decision was reversed the following decade, but the U.S. still did not move toward reprocessing.) But the Department of Energy (DOE) has continued to fund research and development (R&D) on nuclear reprocessing technologies, including new technologies that their proponents claim would reduce the risk of proliferation from reprocessing.
- The report accompanying H.R. 2419, the *Energy and Water Development Appropriations Act for Fiscal Year 2006*, which the House passed in May, directed DOE to focus research in its Advanced Fuel Cycle Initiative program on improving nuclear reprocessing technologies. The report went on to state, “The Department shall accelerate this research in order to make a specific technology recommendation, not later than the end of fiscal year 2007, to the President and Congress on a particular reprocessing technology that should be implemented in the United States. In addition, the Department shall prepare an integrated spent fuel recycling plan for implementation beginning in fiscal year 2007, including recommendation of an advanced reprocessing technology and a competitive process to select one or more sites to develop integrated spent fuel recycling facilities.”
- During floor debate on H.R. 2419, the House defeated an amendment that would have cut funding for research on reprocessing. In arguing for the amendment, its sponsor, Mr. Markey, explicitly raised the risks of weapons proliferation. Specifically, the amendment would have cut funding for reprocessing activities and interim storage programs by \$15.5 million and shifted the funds to energy efficiency activities, effectively repudiating the report language. The amendment was defeated by a vote of 110-312.
- But nuclear reprocessing remains controversial, even within the scientific community. In May 2005, the American Physical Society (APS) Panel on Public Affairs, issued a report, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk*. APS, which is the leading organization of the nation’s physicists, is on record as strongly supporting nuclear power. But the APS report takes the opposite tack of the Appropriations report, stating, “There is no urgent need for the U.S. to initiate reprocessing or to develop additional national repositories. DOE programs should be aligned accordingly: shift the Advanced Fuel Cycle Initiative R&D away from an objective of laying the basis for a near-term reprocessing decision; increase support for proliferation-resistance R&D and technical support for institutional measures for the entire fuel cycle.”
- Technological as well as policy questions remain regarding reprocessing. It is not clear whether the new reprocessing technologies that DOE is funding will be

developed sufficiently by 2007 to allow the U.S. to select a technology to pursue. There is also debate about the extent to which new technologies can truly reduce the risks of proliferation.

- It is also unclear how selecting a reprocessing technology might relate to other pending technology decisions regarding nuclear energy. For example, the U.S. is in the midst of developing new designs for nuclear reactors under DOE's Generation IV program. Some of the potential new reactors would produce types of nuclear waste that could not be reprocessed using some of the technologies now being developed with DOE funding.

5. Brief Overview of Economics of Reprocessing

- The economics of reprocessing are hard to predict with any certainty because there are few examples around the world on which economists might base a generalized model.
- Some of the major factors influencing the economic competitiveness of reprocessing are: the availability and cost of uranium, costs associated with interim storage and long-term disposal in a geologic repository, reprocessing plant construction and operating costs, and costs associated with transmutation, the process by which certain parts of the spent fuel are actively reduced in toxicity to address long-term waste management.
- Costs associated with reducing greenhouse gas emissions from fossil fuel-powered plants could help make nuclear power, including reprocessing, economically competitive with other sources of electricity in a free market.
- It is not clear who would pay for reprocessing in the U.S. The options are: the government paying, the utilities themselves paying (not likely) or consumers paying in the form of higher electric rates. Passing the cost increases on to the consumer may not be as simple as it seems in the context of the current regulatory environment. In States with regulated utilities, regulators generally insist on using the lowest-cost source of electricity available and in States with competing electricity providers, the utilities themselves favor the lowest-cost solutions for the power they provide. To the extent that reprocessing raises the cost of nuclear power relative to other sources, reprocessing would be less attractive in both of these situations. As a result, utilities have shown little interest in reprocessing.
- Three recent studies have examined the economics of nuclear power. In a study completed at the Massachusetts Institute of Technology in 2003, *The Future of Nuclear Power*, an interdisciplinary panel, including Professor Richard Lester, looked at all aspects of nuclear power from waste management to economics to public perception. In a study requested by the Department of Energy and conducted at the University of Chicago in 2004, *The Economic Future of Nuclear*

Power, economist Dr. Donald Jones and his colleague compared costs of future nuclear power to other sources, and briefly looked at the incremental costs of an advanced fuel cycle. In a 2003 study conducted by a panel including Matthew Bunn (a witness at the June 16 hearing) and Professor Steve Fetter, *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*, the authors took a detailed look at the costs associated with an advanced fuel cycle. All three studies seem more or less to agree on cost estimates: the incremental cost of nuclear electricity to the consumer, with reprocessing, could be modest – on the order of 1-2 mills/kWh (0.1-0.2 cents per kilowatt-hour); on the other hand, this increase represents an approximate doubling (at least) of the costs attributable to spent fuel management, compared to the current fuel cycle (no reprocessing). Where they strongly disagree is on how large an impact this incremental cost will have on the competitiveness of nuclear power. The University of Chicago authors conclude that the cost of reprocessing is negligible in the big picture, where capital costs of new plants dominate all economic analyses. The other two studies take a more skeptical view – because new nuclear power would already be facing tough competition in the current market, any additional cost would further hinder the nuclear power industry, or become an unacceptable and unnecessary financial burden on the government.

6. Background

For a detailed background on the advanced fuel cycle (sometimes referred to as the closed fuel cycle), including reprocessing technologies, waste management and non-proliferation concerns, please refer to the charter from our June 16 hearing on *Nuclear Fuel Reprocessing* (attached).

Economic Future of Nuclear Power

The single biggest cost associated with nuclear power is the capital cost, i.e., the upfront money required to build a new plant. The 100+ nuclear plants now operating in the U.S. were built in a highly regulated electricity market in which it was a given that the costs would be passed on to the consumers. As a result, most of the utilities that own these plants today have long since paid off the capital costs. With low operations and maintenance costs, existing plants are competitive with other sources of electric power. Nuclear power currently supplies 20 percent of U.S. electricity and, for some States, nuclear power represents more than 50 percent of their electricity supply. Demand for electricity in the U.S. is growing rapidly. In order for nuclear power to continue to supply at least 20 percent of U.S. electricity, several new plants will need to be built in next 5-10 years. The economic future of nuclear power, however, could depend on the costs of building new plants in either a deregulated, competitive environment, or a regulated environment that favors the lowest-cost option. In both of these cases, the capital costs for new plants are not so easily passed on to the consumers.

In a larger context, concerns about global warming have led to a different view of the economic competitiveness of new nuclear generating capacity. Right now, coal is the cheapest source of electricity, and coal resources are abundant in the U.S. If the government were to enforce a carbon cap or tax on the utilities, the price of coal-fired power would go up. Some utilities and DOE are already investing in technologies to reduce emissions in anticipation of such a cap. DOE's R&D plan for coal calls for greenhouse gas capture and disposal to add no more than 10 percent to the cost of coal-fired power, but it remains unclear to what extent that goal is achievable. In general, any significant changes in energy demand patterns will influence the economic attractiveness of nuclear, a source of power that does not emit greenhouse gases.

Economics of Reprocessing versus Direct Disposal

Spent fuel management is only a small part of the total cost of nuclear power, but it is the part at issue in the reprocessing debate. There is general agreement between economic analyses^{1,2,3} that, given the market price of uranium (approximately \$60/kg), and international experience with reprocessing, it remains cheaper to mine and enrich uranium ore than to reprocess and recycle spent fuel. Other major factors that will influence the economic balance between reprocessing and direct disposal include the costs of uranium enrichment, interim storage, long-term disposal in a geologic repository (including construction costs for the repository), mixed oxide (MOX) fuel fabrication, construction and operation of the reprocessing plant itself, construction and operation of facilities to "burn" or transmute the unusable parts of the waste, and various transportation and security requirements. Good data are available for the costs of enrichment, interim storage, transportation and security. All of the other costs have to be estimated, and estimates vary widely in some cases. There are also (or will also be) differences, for some steps in the fuel cycle, between the underlying costs and the market price. Uranium supply and enrichment, for example, operate in a competitive market environment, keeping the profit margin fairly predictable. On the other hand, a lack of competition in reprocessing and MOX fuel fabrication, at least internationally, results in a more ambiguous relationship between cost and price.

Nuclear power in the U.S. has long been subsidized by the federal government. The commercial nuclear industry grew out of multi-billion dollar government-funded research and development programs on nuclear weapons. The DOE has ongoing programs of research, development and demonstration of advanced nuclear technologies in addition to the Nuclear Power 2010 Program (funded at nearly \$50 million in fiscal year 2005) to subsidize the costs of siting and licensing new commercial reactors this decade. Pending energy legislation in the 109th Congress authorizes continued tax credits and other incentives for future nuclear energy. If the market price of reprocessing is higher than electricity producers are willing or able to bear, and the government decides that the

¹ Harvard University study, Project on Managing the Atom, *The Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel*, December 2003.

² MIT Nuclear Energy Study, *The Future of Nuclear Power*, 2003.

³ University of Chicago Study, *The Economic Future of Nuclear Power*, August 2004

public benefits exceed the costs, some form of government funding will be necessary to bring reprocessing into the nuclear fuel cycle in the U.S.

7. Witness Questions

Dr. Lester:

- Under what conditions would nuclear fuel reprocessing be economically competitive with the open fuel cycle and with other sources of electric power? What major assumptions underlie your analysis? What steps might be available to reduce the costs of reprocessing?
- What would it cost to efficiently manage nuclear waste by further integrating the fuel cycle through development of a system that includes reprocessing, recycling, and transmutation (“burning” the most radioactive waste products in an advanced reactor)?
- What government subsidies might be necessary to introduce a more advanced nuclear fuel cycle in the U.S.? What assumptions underlie those estimates?
- How would a decision to reprocess affect the economic future of nuclear power in the U.S.?

Dr. Jones:

- Under what conditions would nuclear fuel reprocessing be economically competitive with the open fuel cycle and with other sources of electric power? What major assumptions underlie your analysis?
- How will a decision to reprocess affect the economic future of nuclear power in the U.S.?

Dr. Fetter:

- Under what conditions would nuclear fuel reprocessing be economically competitive with the open fuel cycle and with other sources of electric power? What major assumptions underlie your analysis? What steps might be available to reduce the costs of reprocessing?
- What would it cost to efficiently manage nuclear waste by further integrating the fuel cycle through development of a system that includes reprocessing, recycling, and transmutation (“burning” the most radioactive waste products in an advanced reactor)?
- What government subsidies might be necessary to introduce a more advanced nuclear fuel cycle in the U.S.? What assumptions underlie those estimates?

- How would a decision to reprocess affect the economic future of nuclear power in the U.S.?

Mr. Fertel:

- Is there a consensus position among the nuclear plant-owning utilities regarding whether the U.S. should introduce reprocessing into the nuclear fuel cycle within the next five or ten years?
- What government subsidies might be necessary to introduce a more advanced nuclear fuel cycle (that includes reprocessing, recycling, and transmutation—“burning” the most radioactive waste products in an advanced reactor) in the U.S.? What assumptions underlie those estimates?
- How would a U.S. move to reprocessing affect utilities’ long-term business planning?